Structure and Function of the Rectal Epithelium and Anal Glands During Mating Behavior in the Mediterranean Fruit Fly Male[1]

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ABSTRACT

Previous authors have implicated a pair of anal glands as the primary source of the pheromone used in the mating behavior of the Mediterranean fruit fly male. The dissemination of the pheromone is enhanced by the rectal epithelium which is everted and expanded during mating behavior. Observations of the rectal epithelium and anal glands are presented.

INTRODUCTION

The potentially devastating impact of the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), on the multibillion dollar fruit industry in the United States (especially in the states of California, Florida, Texas and Arizona) has been an important factor in the development of an effective control program for this pest. Recent infestations in the Santa Clara Valley of California have resulted in a multimillion dollar eradication program which caused a great deal of public consternation and political turmoil because of controversies over the extensive use of pesticides. Because of this, research continues in areas that can increase the effectiveness of a control program while minimizing the use of potentially dangerous chemical pesticides.

One aspect of the biology of the Mediterranean fruit fly that has received considerable attention, is the mating behavior pattern (Martelli, 1910; Back and Pemberton, 1918; Feron, 1962; Myburgh, 1962; Prokopy and Hendricks, 1979; Arita, 1983; Arita and Kaneshiro, 1983, 1985). An understanding of the complex mate recognition system of this species is important in the successful application of the Sterile Insect Release Method (SIRM) as an effective control tactic for this pest. The success of SIRM depends on the ability of sterilized males to compete with wild males for females under field conditions (Holbrook and Fujimoto, 1970; Arita, 1979).

Arita (1983) and Arita and Kaneshiro (1983, 1985) describe two phases in the mating behavior pattern of *C. capitata*. In the first phase, males form aggregations of courtship territories within the canopy of a host (or non-host) plant. Such aggregations of males are referred to as "leks" and behavioral actions which are displayed during this phase of the mating behavior are referred to as "lek behavior."

In the second phase, the male orients toward the female and begins to display behavioral actions which are cumulatively referred to as "courtship behavior." During the entire courtship sequence prior to mounting the female to achieve intromission, the male curls the terminal end of his abdomen downward with the rectal epithelium still extruding and vibrates his wings. It appears the male vibrates his wings during courtship to move air toward the female he is facing which enhances the movement of the pheromone that is released from the anal glands within the everted rectal epithelium.

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Thus, the extrusion of the rectal epithelium and the release of the pheromone plays an extremely important function in the mating pattern of *C. capitata*. The presence of similar structures and their role have been described in other tephritid species such as *Dacus tryoni* (Fletcher, 1968, 1969), *Anastrepha suspensa* (Nation, 1972), and *Rioxa pornia* (Pritchard, 1967). In this paper, we present observations of the rectal epithelium and the anal glands which are presumed to be the primary source of the pheromone released by *C. capitata* males.

MATERIALS AND METHODS

C. capitata males were immobilized by chilling in a 0°C freezer for 5 minutes. By gently squeezing the midsection of the abdomen with forceps, the rectal epithelium which is normally folded between the anal plates was everted. By examining the membranous rectal epithelium under the dissecting microscope, it was possible to differentiate the structures within the rectal epithelium such as a pair of anal glands. By gently teasing away the sclerotized segments of the exoskeleton, it was possible to view the relationship of the anal glands and the rectal epithelium with that of the alimentary canal.

OBSERVATIONS

When the *C. capitata* male is not pheromone calling or courting females, the terminalia appears as illustrated in Figure 1A. During pheromone calling and also during the courtship phase of the mating pattern, however, the membranous rectal epithelium which is normally folded within the anal plates, is everted and may be expanded into a balloon-like structure. The expanded form of the rectal epithelium appears as illustrated in Figure 1B. When examined under a dissecting microscope, it is possible to see a pair of anal glands (Figure 1C). These glands are presumed to be the primary source of the sex pheromone (Lloste and Roche, 1960). Also, while the rectal epithelium is everted and expanded, it is possible to see a narrow slit on both sides of the balloon-like structure. Presumably it is through these openings that the pheromone is released to the exterior surface of the epithelium. If enough pressure is applied to the abdomen with a pair of forceps, it was possible to force the anal glands through these openings (see Figure 1D) giving the appearance of "horn-like" structures which have, on rare occasions, been observed in live males.

DISCUSSION

A number of secondary sexual structures have been described for *C. capitata* males (Hardy, 1949). For example, the males have a pair of orbital bristles modified into specialized spatulate bristles. Also, on the dorsal and ventral surfaces of the fore femur, there is a dense brush of yellow bristles. Arita (1983) suggested that both structures are utilized in the courtship behavior displayed by the males. The specialized orbital bristle may have evolved to enhance the head movements of males during courtship. Although the function of the brush of bristle on the fore femur is not clear, it is highly probable that it also plays an important role during courtship.

The balloon-like structure formed by the extrusion of the rectal epithelium is perhaps one of the most important of the secondary sexual structures involved in the sexual behavior of *C. capitata*. The inflated rectal epithelium which serves to increase the surface area onto which the pheromone is released, enhances the dispersal of the pheromone (Arita, 1983). The chemical stimulus provided by the release of a pheromone by the male plays an extremely important role in its complex mating

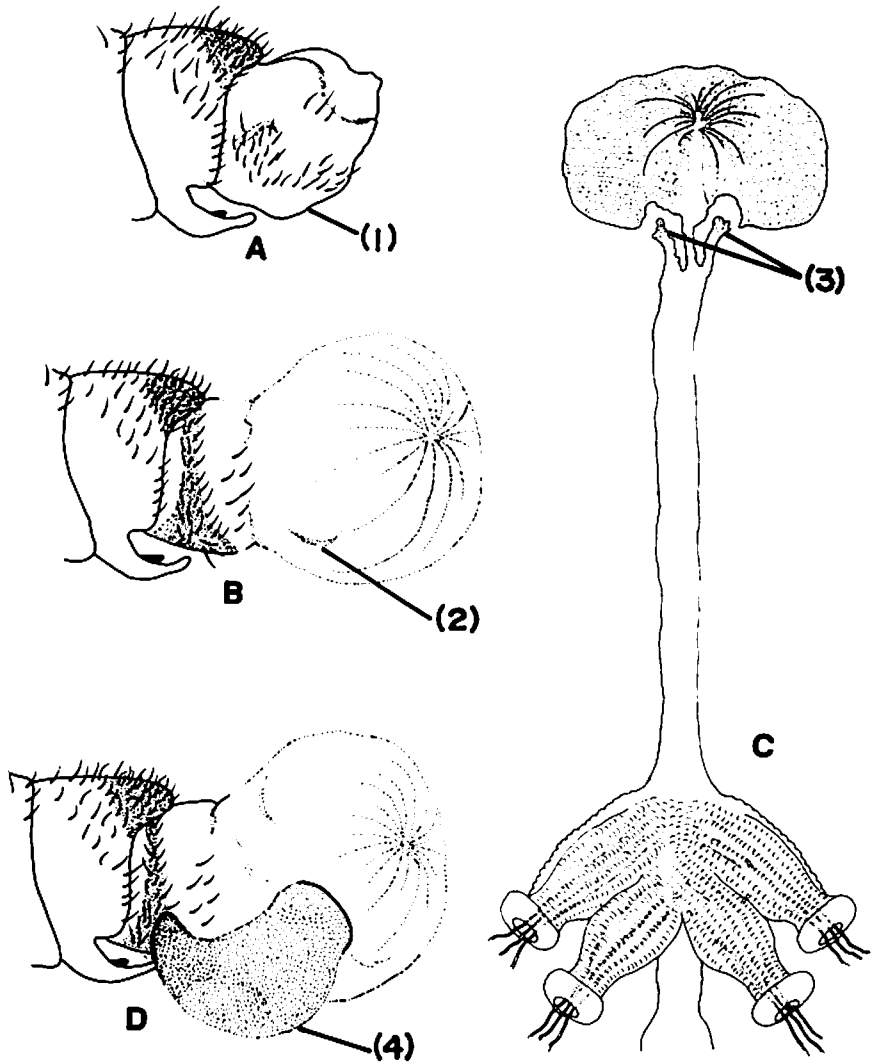

FIGURE 1. A. Terminalia of male *C. capitata* showing normal situation with rectal epithelium folded within anal plates (1). B. Rectal epithelium in expanded "balloon-like" form showing lateral slits (2) through which pheromone is presumably secreted. C. Diagram showing relationship of rectal glands (3) with alimentary canal. D. Rectal glands forced out of rectal epithelium into horn-like structure (4).

ritual. Dispersal of the pheromone is involved in both the lek and courtship phases of the mating pattern and it is apparent that the receptivity threshold of the female is greatly influenced by the male's ability to disperse the pheromone effectively toward the female.

Sexual selection has played a key role in the evolution of the inflatable rectal epithelium by enhancing the male's attractiveness to the females. Arita (1983) and Arita and Kaneshiro (1985) showed that not all males mate and in fact only 60% of the males are successful in mating with females. More significantly, about 15% of the total population of males mate with about 70% of the females (Arita and Kaneshiro, 1985). These data indicate that male mating success is highly competitive and that any behavior or morphological feature which increases a male's mating success should be investigated as an important part of the biology of that species.

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